Operational Experience with Synchrophasors at a National Transmission Operations Center

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Headlines Impact
System Stability

Note the Concentration of Nuclear Plants along the West Edge and the SouthWest
Massive Wind Farms Installed and Planned for the North Sea

8 GW Installed and 2.9Awaiting Installation
TenneT Service Area

Based in the Netherlands and South along Germany’s Western Edge

• 21,000 km 400 and 110 kV lines
• 403 Substations
• 67 GW installed Generation
• 182,000 km² supplied area
Replacing Nuclear with Wind

High Availability
High Inertia
Dynamic Voltage Support

Non-Dispatchable
Low Inertia
No Dynamic Voltage Support
Loss of Northern Power Plant

- **Southern Voltage**
- **Northern Voltage**

Date: Tue 8/11/2009 17:47

Time: 50 55

Voltage: 120000 - 240000
Loss of Northern Power Plant

\[ P = \frac{V_1 V_2 \sin \Theta}{X} \]
Loss of Northern Power Plant

$$P = V_1 V_2 \sin\Theta / X$$

Loss of 80% Power Transfer

Power Oscillation
Frequency Change with Hourly Scheduled Plant Startup - Shutdown

Model Validation, Scheduling Confirmation
System Impact of a Line Trip

Loss of 50 MW Power Transfer

Loss of 13 MVar
System Impact of a Line Trip

System Oscillation
Phasor View in High Load Situation

Parallel Paths Included, Summing Paths not Necessary
Power Swing Recognition, Alarm and Analysis
Power Plant Trip in Southern Area

Loss of about 600 MW
Voltage Oscillations

Magnitude not Bad but Poor Damping
Power Oscillations
Compare Line Trip and Generation Trip

Line Trip

Southern Generator Trip
Conclusions and Future Developments

• Synchrophasors Provide Improved Visualization to Operators of the Severity of System Events
• Different Synchrophasor Views Show Events Better – There is no Single Best Viewer
• Synchrophasors can Reduce the Number of Screens Viewed
• Lower System Intertia Means Faster Event Evolution
• Automatic Action to Mitigate Events Will Be Required